



# Quality Assurance Assessment of Wetland Mapping Layers

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# Table of Contents

|                                                             |    |
|-------------------------------------------------------------|----|
| Executive Summary .....                                     | 5  |
| 1. Introduction .....                                       | 6  |
| 2. Background .....                                         | 7  |
| 3. Objectives .....                                         | 8  |
| 4. Scope of Assessment .....                                | 9  |
| 5. Quality Assurance Methodology .....                      | 10 |
| 5.1 Overview.....                                           | 10 |
| 5.2 Study Area and Wetland Dataset .....                    | 10 |
| 5.3 Data Preparation .....                                  | 10 |
| 5.4 Sampling Design .....                                   | 10 |
| 5.5 Stratified Sampling .....                               | 11 |
| 5.6 Desktop Validation.....                                 | 11 |
| 5.7 Confidence Assessment.....                              | 11 |
| 5.8 Output Data .....                                       | 12 |
| 5.9 Likelihood of Meeting Significant Wetland Criteria..... | 12 |
| 6. Results.....                                             | 14 |
| 6.1 Wetland extent.....                                     | 14 |
| 6.2 QA assessment overview.....                             | 14 |
| 7. Layer-Specific Assessment .....                          | 17 |
| 7.1 Combined Freshwater Wetland Extents.....                | 17 |
| 7.2 Mangroves .....                                         | 19 |
| 7.3 Saltmarsh.....                                          | 21 |
| 7.4 Waterbodies .....                                       | 23 |
| 7.5 Heathlands (including gumlands).....                    | 25 |
| 8. Limitations of the QA Assessment .....                   | 29 |
| 9. Recommendations .....                                    | 30 |
| 10. Recommended Use of Wetland Mapping Layers .....         | 32 |
| 11. Conclusion.....                                         | 33 |
| 12. References.....                                         | 34 |

|                                                              |    |
|--------------------------------------------------------------|----|
| Appendix 1: Author Expertise.....                            | 36 |
| Appendix 2: Wetland data source.....                         | 37 |
| Appendix 3: Imagery Sources Used in Desktop Validation ..... | 38 |
| Appendix 4: Table of Figures .....                           | 39 |

## Executive Summary

Northland Regional Council (NRC) maps the distribution and extent of wetlands across Northland. In 2024 new maps were developed using ecological surveys, aerial imagery, and predictive spatial modelling based on LiDAR (a method of creating highly accurate 3D maps using lasers) and high-resolution imagery. The wetland mapping layers were developed using predictive modelling approaches and should be interpreted as indicative datasets suitable for regional-scale analysis rather than definitive wetland boundaries.

NRC commissioned an independent quality assurance (QA) assessment to evaluate the accuracy, confidence, and limitations of the new maps. The assessment supports transparent communication about how reliable the maps are and provides guidance on appropriate uses.

The new map layers include showing freshwater wetlands, mangrove, saltmarsh, waterbodies (open water such as lakes and dams), and heathland (including gumlands). The assessment covers all these layers. The QA assessed representative wetlands of different sizes, distribution, and land-use contexts. It also included desktop validation using aerial imagery and other spatial information. Accuracy and confidence percentages are based on a stratified random sample of 200 polygons per wetland type, assessed through desktop validation using aerial imagery and spatial data. Each polygon was reviewed to determine whether a wetland was present, whether its boundaries were reasonable and whether the mapped wetland type was plausible.

Mapping accuracy varied across wetland types. At 88% correct, mangroves and saltmarsh were the most accurately mapped. Waterbodies showed moderate accuracy 80% correct, with the difficulty of distinguishing natural waterbodies from farm dams and artificial structures creating most of the uncertainty. Gumlands showed lower accuracy at 68% correct, reflecting the difficulty of distinguishing gumland vegetation from regenerating scrub. Freshwater wetlands were the most challenging wetland type, with only 54% confirmed as correct, reflecting the difficulty of distinguishing wetland vegetation in pasture and wetlands obscured by forests.

Mapping confidence followed a similar pattern, with mangroves the most confidently mapped (98% High confidence) and freshwater wetlands the least (48% Low confidence). This was mainly due to the same difficulty distinguishing wetland vegetation in pasture and modified landscapes, degradation in these areas make it even more difficult to recognise potential wetlands.

The wetland layers support regional understanding of wetland distribution but do not confirm wetland boundaries, types or legal status. Field verification by a suitably qualified wetland specialist remains necessary where site-specific or regulatory decisions are required.

This report:

- assesses mapping confidence across wetland layers;
- identifies common mapping errors and limitations;
- provides guidance on appropriate uses of the datasets; and
- offers recommendations for improving wetland mapping and maintaining an updated wetland inventory.

# 1. Introduction

Northland Regional Council (NRC) maintains several spatial datasets that map the distribution and extent of wetlands across the Northland region. These datasets have been developed over time using a combination of historical ecological survey information, interpretation of aerial imagery (including high resolution oblique imagery using Photoblique<sup>1</sup> viewer) and, more recently, predictive modelling approaches incorporating LiDAR and machine-learning techniques.

Regional-scale wetland mapping provides a general representation of wetland extent that, while not a precise or exact record, can still offer value at a range of scales including, in some contexts, at the property level. Its reliability varies depending on factors such as wetland type, wetland size, surrounding vegetation structure, and the methods used to generate spatial layers. As NRC prepares to make these datasets publicly available, it is important that the strengths and limitations of the mapping are clearly documented so that users can interpret the information appropriately and apply it within its intended scope.

This report presents an independent quality assurance (QA) assessment of NRC's wetland mapping layers. The principal aim of the assessment is to provide a transparent and defensible evaluation of mapping accuracy, confidence, and limitations to inform public release and responsible ongoing use of the datasets. For the purposes of this report, mapping confidence refers to the degree of certainty that a mapped feature represents a genuine wetland, that its boundaries are reasonably accurate, and that any inferred wetland type is plausible, based on desktop assessment of available aerial imagery and spatial data.

The QA assessment comprised a statistically representative sampling framework for desktop validation and an evaluation of mapping performance across different wetland types and environmental settings. The results provide guidance on where the mapping can be applied with confidence and where additional validation may be required.



**Figure 1.** View north over the highest ranked pakihi and gumland wetland, Lake Ohia, Northland (Martin et al., 2011). Photograph: A. Macdonald, Biospatial Ltd, 24 March 2023.

<sup>1</sup> Photoblique is a high-resolution oblique aerial image viewer available under license – e.g. see Figure 1.

## 2. Background

Recent wetland mapping undertaken for Northland has used a combination of remote sensing datasets and predictive modelling approaches (Macdonald et al., 2020). Key inputs include:

- LiDAR-derived terrain information;
- high-resolution aerial imagery;
- historical imagery, including Retrolens datasets; and
- environmental predictors such as topography and wetness indices.

These datasets have been used to generate predictive models (machine learning algorithms) of wetland distribution, producing spatial layers including:

- combined freshwater wetland extents;
- mangrove extent;
- saltmarsh extent;
- waterbodies; and
- heathlands / gumlands.

By integrating large volumes of remote sensing and environmental data, machine learning approaches have substantially extended the spatial coverage of wetland mapping beyond what could be achieved through field survey or manual interpretation alone, enabling a regionally comprehensive picture of wetland distribution across Northland. Importantly, these methods have the potential to identify previously unmapped wetlands, including in areas that have not been subject to systematic field survey, contributing new information to the regional wetland inventory.

Although these datasets represent the most comprehensive wetland mapping currently available for the region, they are indicative (meaning they provide a general representation of wetland distribution rather than a precise or exhaustive record) and have not been comprehensively validated (that is, systematically verified through field inspection across the full extent of the mapped area).

Mapping confidence varies across wetland types and environmental contexts due to distinctive canopy structure or spectral characteristics, such as mangroves, which are generally mapped with relatively high confidence, whereas wetlands beneath closed forest canopy or those structurally similar to surrounding vegetation may be more difficult to detect using remote sensing methods. Nonetheless, the mapping assessment draws on the lead authors' extensive field experience across Northland's wetland environments and previous validation work undertaken in collaboration with the Department of Conservation (DOC), providing a substantive basis for confidence in the mapped outputs.

Guidance for desktop wetland validation has been provided by Bartlam and Burge (2024) in *Wetland delineation using desktop methods: a guide*. Where appropriate, the QA approach used in this report aligns with that guidance, particularly in relation to recording mapping confidence and identifying situations where field verification may be required. Wetland class and type are classified according to the New Zealand wetland classification system of Johnson & Gerbeaux (2004).

### 3. Objectives

The objectives of this Quality Assurance assessment were to:

1. provide a statistically defensible estimate of mapping accuracy and uncertainty based on a representative sample of wetlands;
2. evaluate mapping confidence across different wetland types, size classes, and environmental settings;
3. assess the strengths and limitations of each mapping layer;
4. provide guidance on appropriate uses and limitations of the datasets; and
5. identify opportunities to improve wetland mapping.

## 4. Scope of Assessment

The QA assessment covered the following wetland mapping layers:

- Combined Freshwater Wetland Extents
- Mangrove Extents
- Saltmarsh Extents
- Waterbody Extents
- Heathlands (including Gumlands) – Gumland Extents
- Saltwater Extent Line
- Intertidal Area Layers

The assessment also considered legacy wetland datasets derived from ecological surveys (Ford, 2021; Ford et al., 2021; Ford & Gilbride, 2023, 2024) and DOC's Protected Natural Areas Programme (PNAP) reports where relevant for comparison.

The Northland Combined Freshwater Wetland Extents layer received particular attention within the assessment given that it represents the most comprehensive dataset of inland wetland distribution across the region.

The whole of the region was included in the assessments, including Public Conservation Land (PCL). Although DOC management of PCL might suggest a reduced need for QA, analysis indicates that more than 95% of PCL in Northland sits within land classes where grazing is legally discretionary. Including PCL therefore supports a tenure-neutral understanding of wetland distribution and ensures that a significant portion of regional wetland values is not excluded from assessment.

## 5. Quality Assurance Methodology

### 5.1 Overview

The QA assessment combined several complementary approaches: stratified sampling of mapped wetlands, desktop validation using aerial imagery, comparison with existing ecological datasets, and assessment of mapping confidence. Together these approaches provided a robust framework for evaluating the reliability of the wetland mapping layers.

### 5.2 Study Area and Wetland Dataset

Wetland polygon data were sourced from the NRC wetland geodatabase, which contains mapped extents for five wetland classes: saltmarsh, open water (waterbodies), mangrove, freshwater wetland, and heathland (including gumland)<sup>2</sup>. All spatial processing and analysis was conducted in R (v4.4.1; R Core Team, 2024) using RStudio (v2026.01.1 Build 403) as the integrated development environment, with spatial operations performed using the *sf* package.

To contextualise the extent of wetlands captured in the NRC mapping layers, a comparison of wetland area by wetland class was undertaken between the current NRC dataset (Macdonald et al., 2024) and the priority wetland list compiled by Clarkson & Price (2022), which provides a benchmark of known ecologically significant wetlands across Northland's ecological districts.

### 5.3 Data Preparation

Polygon geometries were validated using *st\_make\_valid()* to correct any topological errors. Non-polygon features (e.g. lines, points) were removed prior to analysis, and all remaining geometries were cast to the multipolygon type for consistency. Where a polygon area attribute (*Shape\_Area*) was not present in the source layer, area was calculated directly from the geometry using *st\_area()*.

Each polygon was assigned a size class based on its area using the thresholds described in Section 5.4. Polygons exceeding 50,000m<sup>2</sup> (5ha) were flagged as potentially ecologically significant, as detailed in Section 5.9.

### 5.4 Sampling Design

A stratified sampling approach was used to select a representative subset of wetlands for validation. Stratification ensures that the sample captures variation in wetland size, spatial distribution, and environmental context. Wetlands were stratified by the following criteria:

#### **Wetland size**

Wetlands were assigned to one of six size classes:

- < 50m<sup>2</sup>
- 50 – 500m<sup>2</sup>
- 500 – 2,000m<sup>2</sup>
- 2,000 – 5,000m<sup>2</sup>
- 0.5 – 5ha
- > 5ha.

These size classes were designed to ensure sampling was distributed across a broad and unbiased range of wetland sizes.

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<sup>2</sup> Appendix 2: Includes the full metadata for the mapping layers

## Land-use context

Wetlands were also stratified by surrounding land use where possible, using the high-resolution NRC land-use information layer (Law & Ardo, 2023). This dataset classifies land use across the region using the Australian Land Use and Management (ALUM) classification hierarchy, integrating a range of regional and national datasets including climate variables, geology, and topography. Land-use context was recorded using the layer's own classification categories, including grazing modified pastures, residual native cover, marsh / wetland, and estuarine and coastal contexts.

## 5.5 Stratified Sampling

A stratified random sample of up to 200 polygons was drawn from each wetland class, with sample targets allocated across size classes to ensure representation of both small and large wetland patches (Table 1). Where fewer polygons were available than the target for a given stratum, all available polygons were included. Sampling was performed with a fixed random seed (123) to ensure reproducibility. The complete sampling frame and site list for all assessed polygons are provided in Appendix 2.

**Table 1.** Target sample sizes by size class (per wetland type)

| Size class                  | Target n   |
|-----------------------------|------------|
| < 50m <sup>2</sup>          | 10         |
| 50 – 500m <sup>2</sup>      | 40         |
| 500 – 2,000m <sup>2</sup>   | 50         |
| 2,000 – 5,000m <sup>2</sup> | 40         |
| 0.5 – 5 ha                  | 35         |
| > 5 ha                      | 25         |
| <b>Total</b>                | <b>200</b> |

## 5.6 Desktop Validation

Selected wetlands were assessed using desktop analysis of spatial datasets, including recent aerial imagery, historical aerial imagery, oblique imagery and LiDAR terrain derivatives.

Each wetland was assessed to determine whether a wetland appears to exist at the mapped location; whether mapped boundaries appear reasonable; and whether the mapped feature is likely to represent a natural wetland. Where possible, additional observations were made regarding likely wetland type. Imagery sources and capture dates used in the desktop validation are documented in Appendix 2.

## 5.7 Confidence Assessment

Mapping confidence was recorded for three components: existence / naturalness (likelihood that a natural wetland occurs at the mapped location), boundary accuracy (how well mapped boundaries reflect visible wetland extent), and type inference (whether the mapped wetland type is plausible).

Confidence levels were categorised as follows in accordance with Bartlam and Burge (2024):

- **High** — the feature is clearly identifiable from aerial imagery with little ambiguity; the mapped wetland, its boundaries, and/or its type are considered reliable.
- **Medium** — some uncertainty exists; the assessment is considered reasonable but further review or additional imagery may be beneficial.
- **Low** — significant uncertainty exists; field verification is recommended and the wetland has been flagged as a priority for in-field assessment.

## 5.8 Output Data

Sampled polygons were reprojected to WGS84 (EPSG:4326) and exported as GeoPackage files (.gpkg) for use in GIS. Centroid coordinates (longitude and latitude) were appended to each record to support field navigation. A set of QA attribute fields was added to each sampled polygon to record field verification outcomes, including wetland existence, boundary accuracy, wetland type confirmation, land use context, and assessor confidence. Combined outputs across all five wetland classes were exported as both a GeoPackage and an Excel workbook for field use and reporting.

## 5.9 Likelihood of Meeting Significant Wetland Criteria

Regional Plan provisions include size thresholds for determining whether wetlands qualify as significant natural wetlands under the *Regional Policy Statement for Northland (NRC, 2016), Appendix 5, Areas of significant indigenous vegetation and significant habitats of indigenous fauna in terrestrial, freshwater and marine environments*. Significance thresholds vary by wetland type; for example, gumland qualifies as significant at just 0.2ha. The decision logic applied in this assessment is summarised in Figure 2.

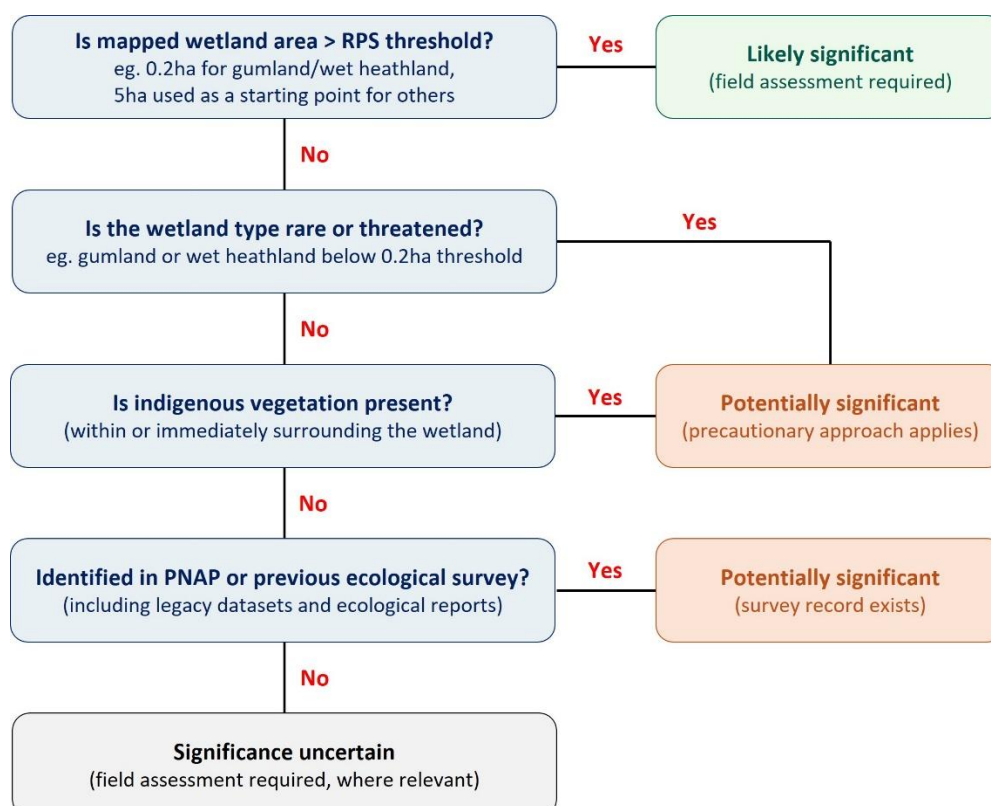


**Figure 2.** Decision logic for assessing the likelihood of wetland significance under the Northland Regional Policy Statement (NRC, 2016). Mapping indicates likelihood only and does not constitute a determination of significance under statutory criteria.

For the purposes of this assessment, wetlands with a mapped area of 5ha or greater ( $\geq 50,000\text{m}^2$ ) were used as a conservative starting point for flagging potentially significant wetlands across all layers. This threshold was chosen to provide a regionally consistent and defensible screening tool, recognising that many wetlands below this size, particularly gumlands, may also meet significance criteria under the Regional Policy Statement (RPS) and should not be assumed to be insignificant on the basis of area alone.

Additionally, significance criteria under the RPS include a requirement that wetlands contain more than 50% indigenous vegetation cover, which cannot be reliably determined from the mapping alone and reinforces the need for field verification where significance is being assessed.

Larger wetlands are more likely to meet significance criteria, particularly where indigenous vegetation is present and where wetlands are identified in previous ecological surveys. However, confirmation of significance for any wetland typically requires ecological field assessment by a qualified wetland specialist.

## 6. Results

### 6.1 Wetland extent

The NRC machine-learning predictive mapping layers (Macdonald et al., 2024) capture wetland extent across five wetland classes, totalling 247,825 polygons and approximately 87,446ha across the Northland region (Table 2). This represents a substantial expansion in mapped wetland coverage compared to the previous wetland layers (Northland Regional Council, 2016), which covered 1046 polygons and 32,064.6ha. This formed the basis for the 61 priority wetlands identified by Clarkson & Price (2022) to support regional monitoring. The difference in total area reflects both the broader spatial coverage of the machine learning approach and its ability to detect smaller and previously unmapped wetlands across the region. Freshwater wetlands represent the largest mapped class by polygon count (99,525 polygons, 43,279ha).

The expanded coverage of the NRC mapping layers suggests that machine learning has identified a large number of wetlands not previously recorded. The accuracy of these additional polygons varies by wetland type and size class, as documented in the QA assessment presented in this report, with field verification recommended where site-specific or regulatory decisions are required.

**Table 2.** Comparison of wetland extent between the NRC mapping layers (Macdonald et al., 2024) and the priority wetland inventory of Clarkson & Price (2022). Freshwater wetlands in Clarkson & Price (2022) combine swamp, fen, marsh, and bog classes.

| Wetland class       | Macdonald et al. (2024) polygons (n) | Macdonald et al. (2024) total (ha) | NRC 2016 polygons (n) | NRC 2016 total (ha) |
|---------------------|--------------------------------------|------------------------------------|-----------------------|---------------------|
| Freshwater wetlands | 99,525                               | 43,279.1                           | 903                   | 23,276.0            |
| Mangrove            | 80,409                               | 13,403.6                           | —                     | —                   |
| Saltmarsh           | 10,072                               | 3,123.1                            | 77                    | 1,099.7             |
| Gumland             | 5,376                                | 21,179.3                           | 29                    | 7,688.9             |
| Waterbodies         | 52,443                               | 6,461.1                            | —                     | —                   |
| <b>Total</b>        | <b>247,825</b>                       | <b>87,446.2</b>                    | <b>1,046</b>          | <b>32,064.6</b>     |

### 6.2 QA assessment overview

A total of 1,000 wetland polygons were assessed across five wetland classes (200 per class) through desktop validation. Results are summarised by wetland type (Table 3) and wetland type mapping confidence (Table 4), with detailed layer-specific results presented in Section 7.

**Table 3.** Wetland type accuracy summary by wetland type (n = 200 per wetland class). Uncertain includes polygons assessed as Maybe or Partly correct.

| Wetland layer       | % Correct | % Uncertain | % Incorrect |
|---------------------|-----------|-------------|-------------|
| Freshwater wetlands | 53.5%     | 42.5%       | 4.0%        |
| Mangroves           | 88.0%     | 2.5%        | 9.5%        |
| Saltmarsh           | 88.0%     | 12.0%       | 0.0%        |
| Waterbodies         | 79.5%     | 16.5%       | 4.0%        |
| Gumlands            | 68.0%     | 31.5%       | 0.5%        |

**Table 4.** Mapping confidence summary by wetland type.

| Wetland layer        | % High confidence | % Medium confidence | % Low confidence | Main sources of uncertainty                                                                     |
|----------------------|-------------------|---------------------|------------------|-------------------------------------------------------------------------------------------------|
| Freshwater wetlands* | 30.2%             | 21.9%               | 47.9%            | Difficulty distinguishing pastoral wetlands and wetlands with forest canopies                   |
| Mangroves*           | 97.8%             | 0.6%                | 1.7%             | Some riparian vegetation mistaken for mangroves                                                 |
| Saltmarsh            | 83.0%             | 9.5%                | 7.5%             | Boundary delineation is difficult where saltmarsh grades into mangrove                          |
| Waterbodies*         | 74.5%             | 18.2%               | 7.3%             | Small areas, difficult to distinguish from aerial imagery                                       |
| Gumlands*            | 50.8%             | 48.2%               | 1.0%             | Difficulty distinguishing from regenerating scrub and identifying whether a hard pan is present |

\*Freshwater wetlands: n = 192, excluding eight incorrectly typed polygons. Mangroves: n = 181, excluding 19 incorrectly typed polygons. Waterbodies: n = 192, excluding eight incorrectly typed polygons. Gumlands: n = 199, excluding one incorrectly typed polygon.

Mapping confidence varied markedly across wetland types, reflecting differences in the structural and visual distinctiveness of each community from aerial imagery. Mangroves were mapped with the highest confidence, consistent with their distinctive canopy structure and coastal setting. Saltmarsh also showed strong confidence, though uncertainty arose where saltmarsh grades into mangrove along shared boundaries. Waterbodies showed moderate confidence, with small waterbodies sometimes difficult to distinguish from aerial imagery. Gumlands showed an almost even split between high and medium confidence, reflecting the challenge of distinguishing gumland vegetation from regenerating scrub. Freshwater wetlands were the most difficult to map confidently, with nearly half of polygons assessed as low confidence, driven by difficulty distinguishing wetland vegetation in pastoral landscapes and wetlands obscured by forest canopies.

Wetland type accuracy was generally highest in the larger size classes across all wetland types, with incorrect or uncertain assignments concentrated in polygons below 500m<sup>2</sup>, where limited image resolution and transitional vegetation communities make confident identification from aerial imagery most difficult.

The QA output data, including per-polygon confidence ratings, wetland type assessments, and land use context, can be incorporated into future mapping and model training workflows. These validated records provide labelled ground-truth data that can be used to refine machine learning models, improve stratified sampling frameworks, and prioritise polygons for field verification in subsequent QA rounds.

## 7. Layer-Specific Assessment

This section presents the results of the desktop validation assessment for each wetland mapping layer. Five wetland classes were assessed:

- freshwater wetlands (Northland Combined Freshwater Wetland Extents);
- mangroves;
- saltmarsh;
- waterbodies; and
- heathlands (including gumlands).

Connected saltwater extent line and intertidal area layers were used as supporting spatial context during validation of the intertidal wetland classes (mangroves and saltmarsh) but were not assessed as standalone layers.

Each layer is evaluated in terms of wetland type accuracy, mapping confidence, mapping performance by size class, ecological significance, and land use context. Results are based on a stratified random sample of 200 polygons per wetland class (n = 1,000 total), drawn across size classes and spatial extent as described in Section 5.

### 7.1 Combined Freshwater Wetland Extents

The Northland Combined Freshwater Wetland Extents layer integrates multiple data sources and represents the most comprehensive mapping of freshwater wetlands across the Northland region. This layer encompasses freshwater wetland classes including swamps, bogs, fens, seepages, shallow water, marshes and wet modified grassland, but excludes mangroves, saltmarsh, waterbodies, and heathlands (including gumlands), which are mapped as separate layers and assessed independently in this report.

Of the 200 polygons assessed during desktop validation, eight were recorded as incorrectly typed in the accuracy assessment, with seven recorded as a wetland class other than freshwater wetland (five as gumland, one as pasture, one as pond) and one was not a wetland.

Freshwater wetlands were the most challenging wetland type to map accurately, reflecting the difficulty in distinguishing wetland vegetation from adjacent non-wetland communities using aerial imagery alone, particularly in pastoral landscapes where wetlands are often degraded or indistinct. Of the 200 polygons assessed, 78 were flagged as grazed pastoral wetlands requiring field verification to assess the dominance of native and wetland-adapted species. In several cases it also appeared that the true extent of pastoral wetlands may be larger than indicated by the mapped polygons, though field verification would be required to confirm this.

Forest canopy presented an additional challenge, obscuring wetland vegetation in a number of polygons and preventing confident assessment from aerial imagery alone. Where closed canopy forest occurs over wetland areas, the underlying vegetation community and wetland boundaries cannot be reliably determined without field verification. This is particularly relevant in areas of regenerating native forest and plantation forestry, where canopy cover may conceal wetlands that are otherwise not detectable from desktop analysis.

#### **Wetland type accuracy**

The wetland class was confirmed as accurate in 107 polygons (53.5%), uncertain in 85 (42.5%), and incorrect in eight (4.0%), including seven polygons recorded as a different wetland class. The high proportion of uncertain assessments reflects the inherent difficulty in confirming freshwater wetland identity from aerial imagery, particularly for smaller polygons where vegetation detail is limited.

Accuracy was highest in the larger size classes, with the >5ha class having 20 confirmed correct and only one uncertain. Incorrect or uncertain assignments were most common in the 50–500m<sup>2</sup> and 500–2,000m<sup>2</sup> classes.

### Freshwater wetland — Wetland class accuracy by size class

n = 200

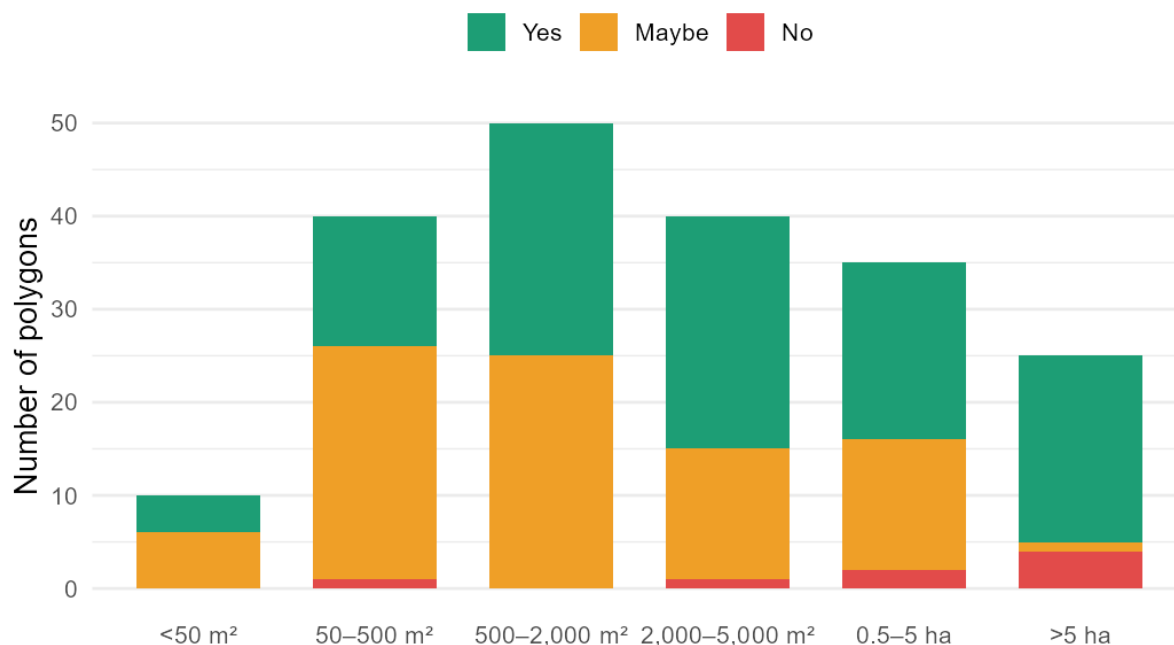


**Figure 3.** Wetland class accuracy by size class for sampled freshwater wetland polygons (n = 200). Dark green = accurate wetland class (Yes); amber = uncertain (Maybe); red = inaccurate (No).

### Confidence

Overall mapping confidence was low relative to other wetland types, with 92 polygons (47.9%) rated as Low confidence, 42 (21.9%) as Medium confidence, and 58 (30.2%) as High confidence. The eight polygons assessed as incorrectly typed were excluded from this summary. This distribution reflects the difficulty in confirming freshwater wetland boundaries and vegetation type from aerial imagery, particularly within pastoral and modified landscapes.

### Freshwater wetland — Confidence rating (confirmed and uncertain polygons)

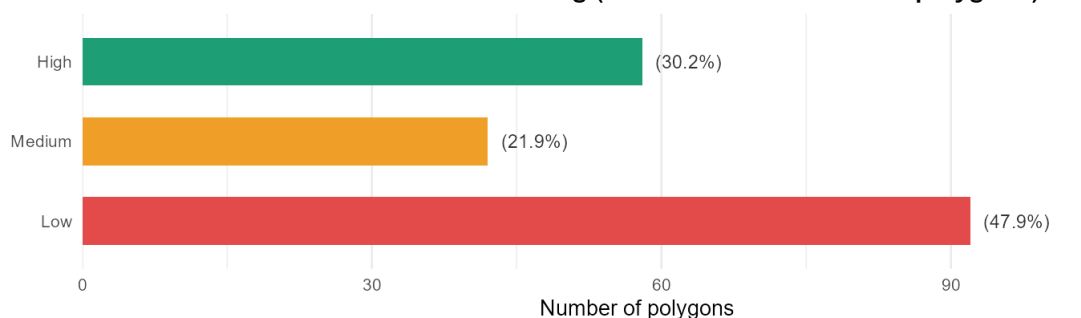
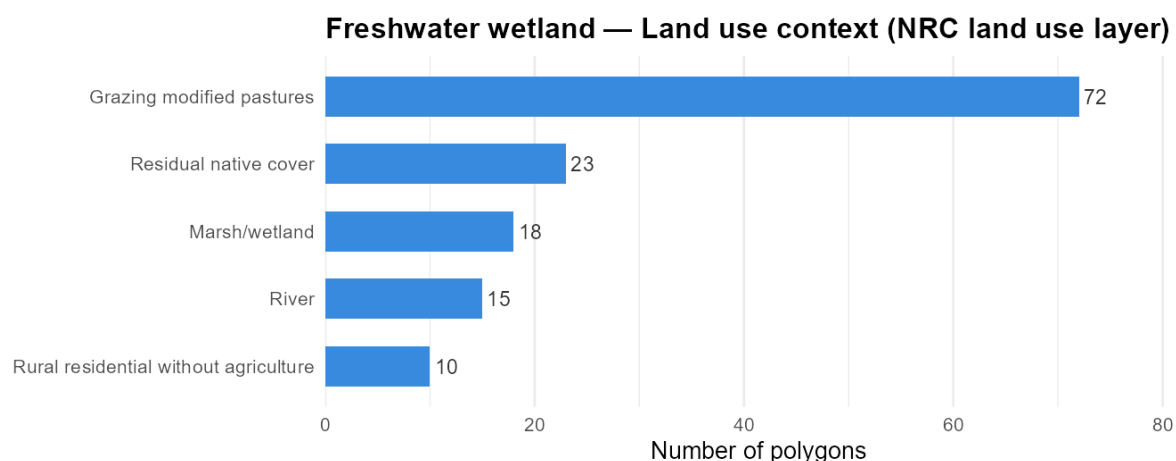


**Figure 4.** Confidence ratings for sampled freshwater wetland polygons (n = 192, excluding eight incorrectly typed polygons). High confidence = 58, Medium confidence = 42, Low confidence = 92.

## Land use context

Freshwater wetland polygons occurring within pastoral land use contexts dominated the sample. The five most common land use categories for polygons confirmed or uncertain as freshwater wetland (excluding eight incorrectly typed polygons) were grazing modified pastures (72 polygons), residual native cover (23 polygons), marsh/wetland (18 polygons), river (15 polygons), and rural residential without agriculture (10 polygons). The dominance of grazing modified pastures in a potentially degraded condition reflects the high proportion of freshwater wetlands occurring within or adjacent



to farmed land across Northland.

**Figure 5.** Land use context for freshwater wetland polygons ( $n = 192$ , excluding eight incorrectly typed polygons), showing the five most common categories based on NRC high-resolution land use data.

## Significant wetlands

Twenty-five freshwater wetland polygons were in the >5ha size class and flagged as potentially ecologically significant. Of these, four were recorded as a different wetland class during desktop validation and are treated as incorrectly typed, leaving 21 confirmed or uncertain freshwater wetland polygons in this size class.

## 7.2 Mangroves

A total of 200 mangrove polygons were assessed through desktop validation. The assessment was informed by the connected saltwater extent line and Northland intertidal area layers, which were used to provide spatial context for boundary delineation. Mangroves were mapped with high overall accuracy, reflecting the structural distinctiveness of mangrove vegetation, which is readily identifiable from aerial imagery across most size classes.

## Wetland type accuracy

The wetland type was correctly identified in 176 polygons (88%), 19 (9.5%) were assessed as incorrect, four (2%) as uncertain, and one (0.5%) as partly correct. Incorrect or uncertain type assignments were concentrated in the smaller size classes, particularly those below 2,000m<sup>2</sup>, with all polygons in the 2,000–5,000m<sup>2</sup>, 0.5–5ha, and >5ha size classes correctly typed. Of the 19 incorrectly typed polygons, two were confirmed as non-wetlands and 17 as genuine wetlands assigned to the wrong type.

Across the 181 correctly, partly correct or uncertainly typed polygons, all were confirmed as natural wetlands with no constructed wetlands recorded. All 25 polygons greater than 5ha and all 40 polygons in the 2,000–5,000m<sup>2</sup> class were correctly typed. Incorrect or uncertain type assignments were most common in the 50–500m<sup>2</sup> and 500–2,000m<sup>2</sup> classes, where smaller or transitional features were occasionally misidentified as saltmarsh, scrub, or riparian vegetation.

## Mangrove - Wetland type accuracy by size class

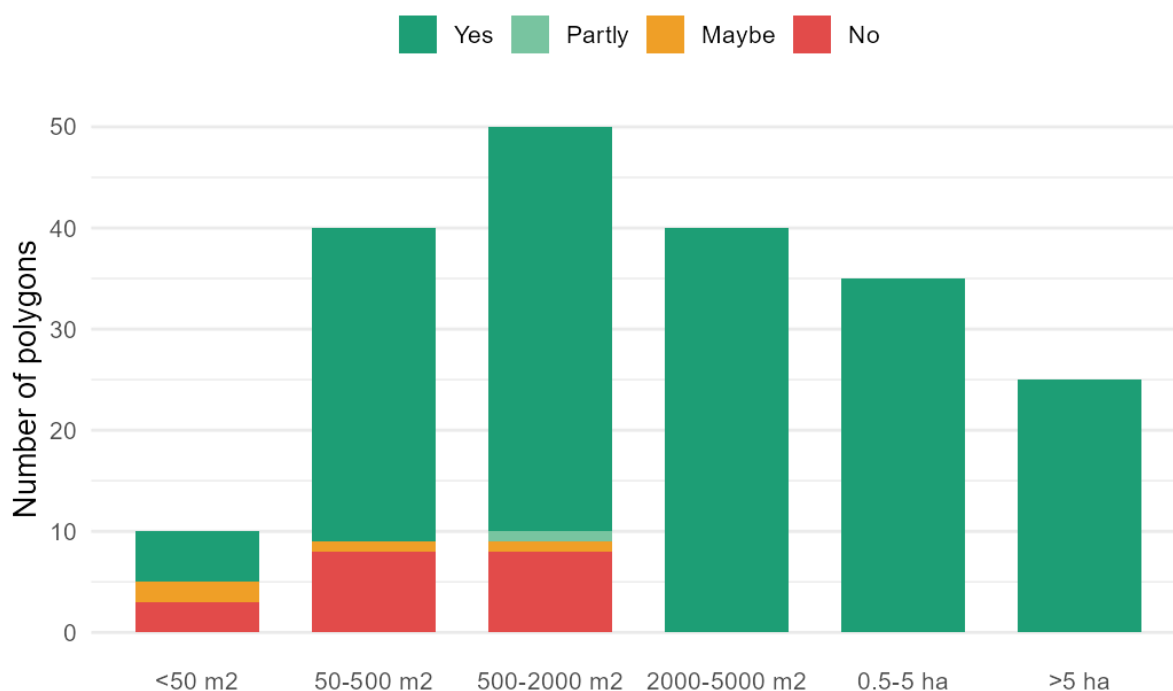


**Figure 6.** Wetland type accuracy by size class for sampled mangrove polygons ( $n = 200$ ). Dark green = correct wetland type (Yes); light green = partially correct (Partly); amber = uncertain (Maybe); red = incorrect wetland type (No).

## Confidence

Overall mapping confidence was very high, with 177 polygons (97.8%) rated as High confidence, one (0.6%) as Medium confidence, and three (1.7%) as Low confidence. Incorrectly typed polygons were excluded from this summary. This result reflects the structural distinctiveness of mangrove vegetation, which is readily identifiable from aerial imagery across most size classes.

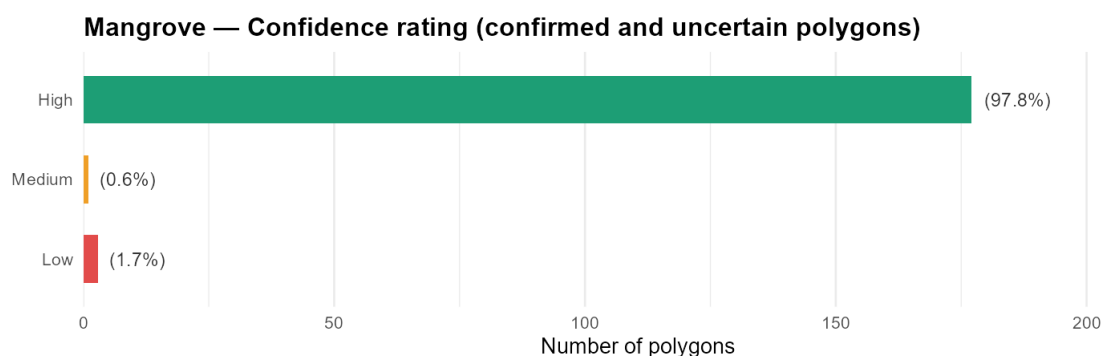


**Figure 7.** Confidence ratings for sampled mangrove polygons ( $n = 181$ , excluding incorrectly typed polygons). High confidence = 177, Medium confidence = 1, Low confidence = 3.

## Significant wetlands

Twenty-five mangrove polygons were flagged as potentially ecologically significant ( $\geq 5$ ha). All 25 were correctly typed and rated High confidence, indicating that large mangrove stands are reliably captured and accurately classified in the mapping.

## Land use context

The majority of mangrove polygons occurred within saline marsh / wetland or estuary contexts, consistent with the coastal intertidal habitat of mangrove vegetation. Based on NRC high-resolution land use data, the five most common land use categories were Marsh / wetland — saline (163 polygons), River (5 polygons), Estuary / coastal waters (4 polygons), Strict nature reserve (2 polygons), and Residual native cover (2 polygons).

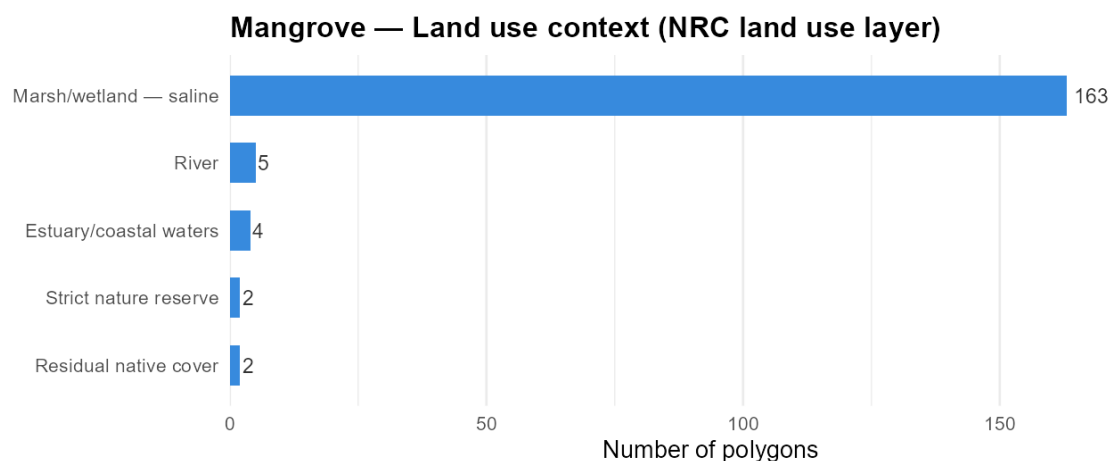


**Figure 8.** Land use context for mangrove polygons ( $n = 176$ , excluding incorrectly typed polygons), showing the five most common categories based on NRC high-resolution land use data.

## 7.3 Saltmarsh

A total of 200 saltmarsh polygons were assessed through desktop validation. The assessment was informed by the connected saltwater extent lines and Northland intertidal area layers, which were used to provide spatial context for boundary delineation. Saltmarsh mapping showed relatively high overall accuracy, with all 200 polygons assessed as either correctly typed or uncertain and none assessed as incorrect. This reflects the visual distinctiveness of saltmarsh vegetation in estuarine and coastal contexts, though confidence was more variable than for mangroves, consistent with the sensitivity of saltmarsh boundaries to tidal stage and seasonal vegetation patterns.

### Wetland type accuracy

The wetland type was correctly identified in 176 polygons (88.0%), while 24 (12.0%) were assessed as uncertain (Maybe). No polygons were assessed as incorrect or partially correct. Uncertain type assignments were concentrated in the smaller size classes, particularly those below 2,000m<sup>2</sup>, where small or transitional saltmarsh patches were difficult to distinguish from adjacent mangrove or estuarine vegetation using aerial imagery alone. Uncertain type assignments were most common in the 50–500m<sup>2</sup> class (12 of 40 polygons, 30%), where small saltmarsh patches embedded within mangrove or estuarine margins were difficult to characterise confidently from available imagery. All polygons in the 0.5–5ha and >5ha size classes were correctly typed, with all 35 polygons in the 0.5–5ha class and all 25 polygons greater than 5ha confirmed as accurate.

Several saltmarsh polygons were also noted to contain areas of mangrove vegetation, suggesting that some mapped units may represent transitional communities where saltmarsh and mangrove are intergrading rather than discrete saltmarsh stands. In a number of cases, saltmarsh extent was also observed to be larger than that mapped, with vegetation characteristic of saltmarsh appearing to extend beyond polygon boundaries in aerial imagery, which may reflect conservative boundary placement or temporal changes in saltmarsh extent since mapping was undertaken. Of the 200 polygons assessed, 199 were confirmed as natural wetlands and one was uncertain as it was possibly artificially constructed.

## Saltmarsh - Wetland type accuracy by size class

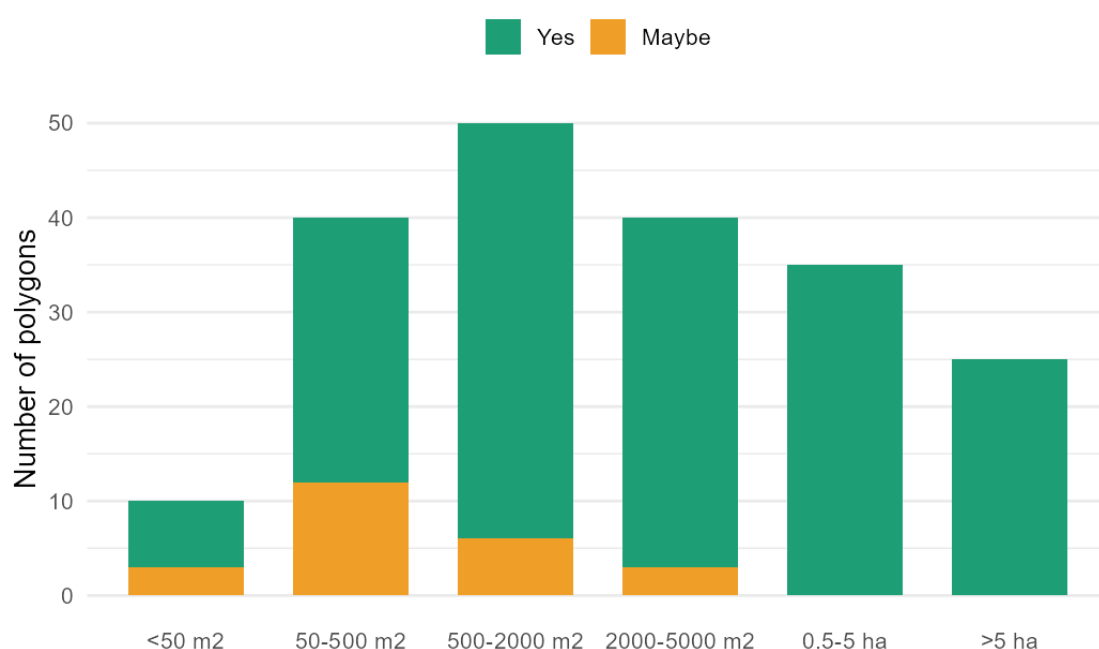


**Figure 9.** Wetland type accuracy by size class for sampled saltmarsh polygons ( $n = 200$ ). Dark green = correct wetland type (Yes); amber = uncertain (Maybe).

## Confidence

Overall mapping confidence was high, with 166 polygons (83.0%) rated as High confidence, 19 (9.5%) as Medium confidence, and 15 (7.5%) as Low confidence. Lower confidence ratings compared to mangroves reflect the inherent difficulty in delineating saltmarsh boundaries from aerial imagery, particularly where saltmarsh grades into mangrove, rushland, or intertidal mud.

## Saltmarsh — Confidence rating distribution

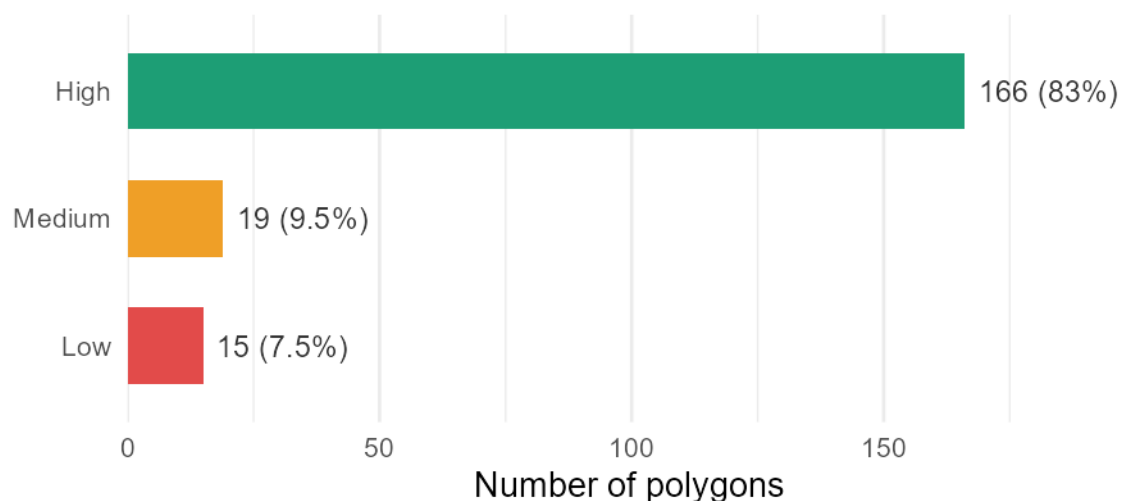


**Figure 10.** Confidence ratings for sampled saltmarsh polygons ( $n = 200$ ). High confidence = 166, Medium confidence = 19, Low confidence = 15.

## Significant wetlands

Twenty-five saltmarsh polygons were flagged as potentially ecologically significant ( $\geq 5\text{ha}$ ). All 25 were correctly typed, with 23 (92%) rated as High confidence and two (8%) as Medium confidence, indicating that large saltmarsh stands are reliably captured in the mapping and consistent with the greater visibility and extent of significant saltmarsh areas in aerial imagery.

## Land use context

The majority of saltmarsh polygons occurred within estuarine contexts, consistent with the ecology of saltmarsh as a coastal intertidal community. Based on NRC high-resolution land use data, saltmarsh polygons were almost entirely classified as Marsh/wetland — saline (199 polygons), with one polygon occurring within Estuary/coastal waters — conservation. This near-uniform land use classification reflects the accuracy of the NRC layer in capturing the intertidal saline character of saltmarsh habitats across Northland.

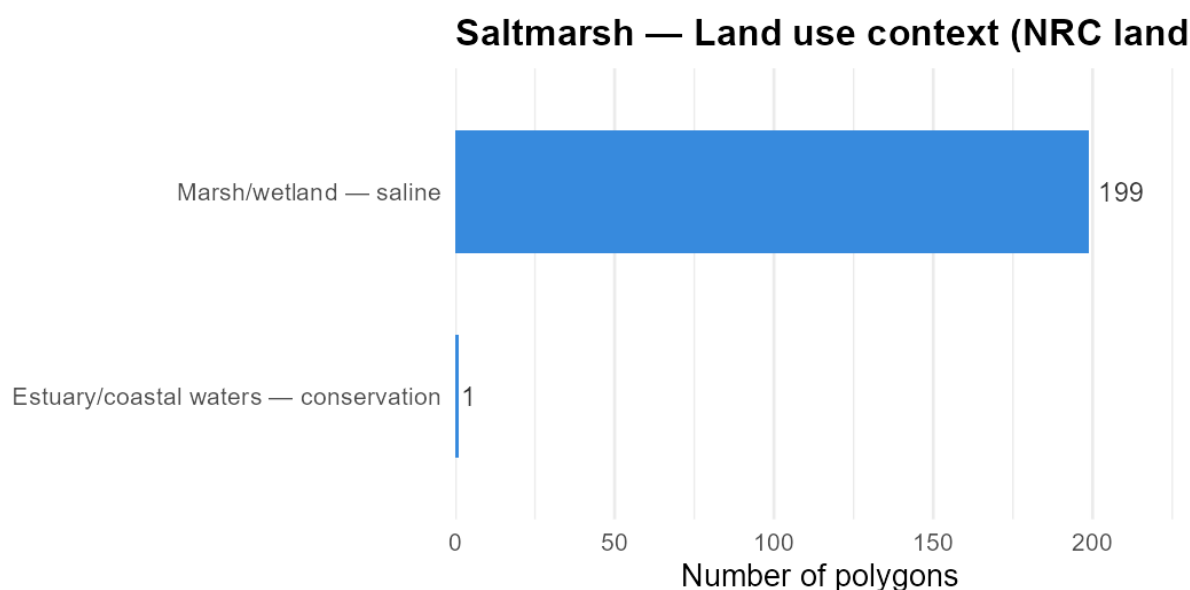


**Figure 11.** Land use context for saltmarsh polygons ( $n = 200$ ), based on NRC high-resolution land use data. Marsh/wetland — saline was the dominant context (199 polygons), with one polygon occurring within Estuary/coastal waters — conservation.

## 7.4 Waterbodies

A total of 200 waterbody polygons were assessed through desktop validation. Mapping confidence was generally high, though uncertainty was more common than for mangroves, reflecting the difficulty in distinguishing natural waterbodies from artificial waterbodies such as farm dams and reservoirs.

### Wetland type accuracy

The wetland type was correctly identified in 159 polygons (79.5%), while 33 (16.5%) were assessed as uncertain and eight (4.0%) as incorrect. Incorrect or uncertain type assignments were concentrated in the smaller size classes, particularly those below  $500\text{m}^2$ , where distinguishing natural waterbodies from artificial structures was most challenging.

Uncertainty was most common in the  $50\text{--}500\text{m}^2$  class (14 of 40 polygons, 35%), followed by the  $0.5\text{--}5\text{ha}$  class (8 of 35 polygons, 23%) and the  $<50\text{m}^2$  class (4 of 10 polygons, 40%). Accuracy was highest in the larger size classes, with all 25 polygons greater than  $5\text{ha}$  correctly typed and 37 of 40 polygons in the  $2,000\text{--}5,000\text{m}^2$  class correctly identified.

Of the 192 polygons confirmed or uncertain as waterbodies, 58 (30.2%) were confirmed as natural, 104 (54.2%) as artificial, 16 (8.3%) as probably natural, 11 (5.7%) as probably artificial, and three (1.6%) were uncertain. The high proportion of artificial waterbodies reflects the prevalence of farm dams across Northland's agricultural landscape and the inherent difficulty in distinguishing natural waterbodies from constructed structures using aerial imagery alone.

## Waterbodies — Wetland type accuracy by size class

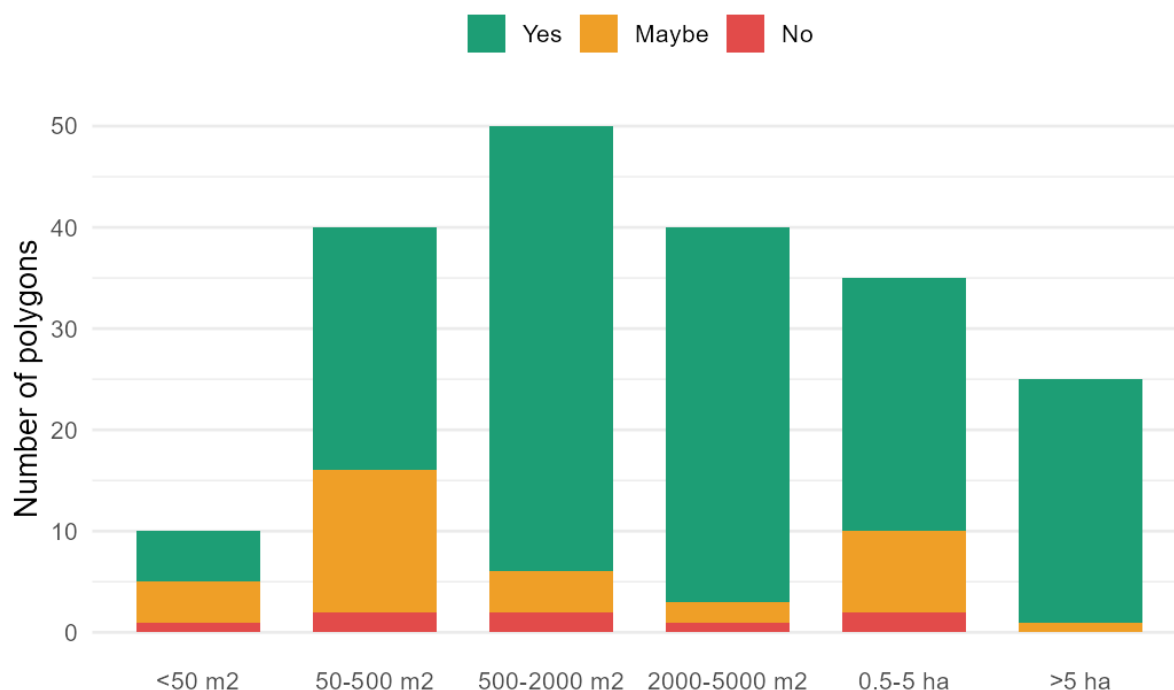


**Figure 12.** Wetland type accuracy by size class for sampled waterbody polygons ( $n = 200$ ). Dark green = correct wetland type (Yes); amber = uncertain (Maybe); red = incorrect wetland type (No).

## Confidence

Overall mapping confidence was moderate, with 143 polygons (74.5%) rated as High confidence, 35 (18.2%) as Medium confidence, and 14 (7.3%) as Low confidence. The eight polygons assessed as incorrectly typed were excluded from this summary. Lower confidence ratings relative to mangroves and saltmarsh reflect the difficulty in distinguishing smaller waterbodies from aerial imagery alone, as well as the possibility that some waterbodies may be seasonal or ephemeral in nature.

### Waterbodies — Confidence rating (confirmed and uncertain polygons)

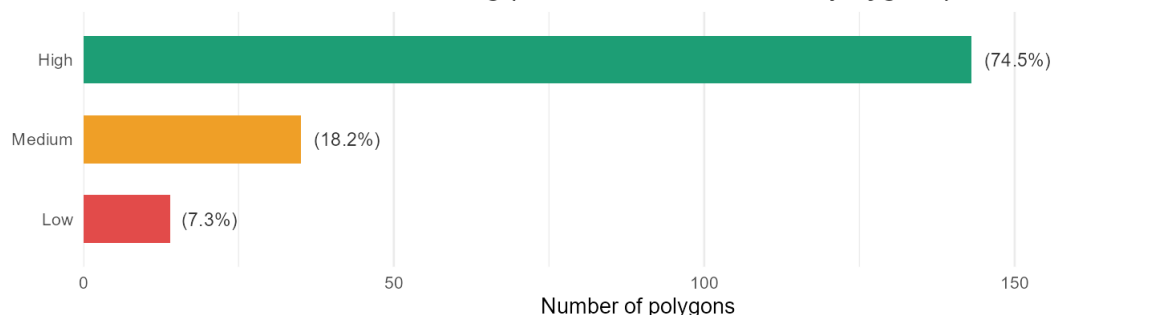


**Figure 13.** Confidence ratings for sampled waterbody polygons ( $n = 192$ , excluding eight incorrectly typed polygons). High confidence = 143, Medium confidence = 35, Low confidence = 14.

## Significant wetlands

Of the 25 potentially significant waterbody polygons, 17 were confirmed as natural, six as artificial, and two were uncertain as to their origin. All 25 were correctly typed, with 23 rated as High confidence and two as Medium confidence, indicating that large waterbodies are reliably captured and accurately classified in the mapping.

## Land use context

Waterbody polygons occurred across a range of land use contexts, reflecting the diversity of natural and artificial waterbodies across the Northland landscape. Based on NRC high-resolution land use data, the five most common land use categories were Lake (54 polygons), Grazing modified pastures (46 polygons), Marsh/wetland (22 polygons), Lake — Conservation (13 polygons), and Marsh/wetland — Conservation (8 polygons). The prevalence of grazing modified pastures reflects the high proportion of farm dams and ponded areas within agricultural land, while lake and lake — conservation contexts represent natural open water features, many of which are likely to meet significance criteria given their size and conservation status.

Of the waterbody polygons assessed, 36 were noted as dune lakes or probable dune lakes during desktop validation, reflecting the concentration of natural waterbodies within Northland's coastal dune systems. Several of these were flagged as potentially seasonal or ephemeral in nature, and some were difficult to distinguish from farm dams without field verification.

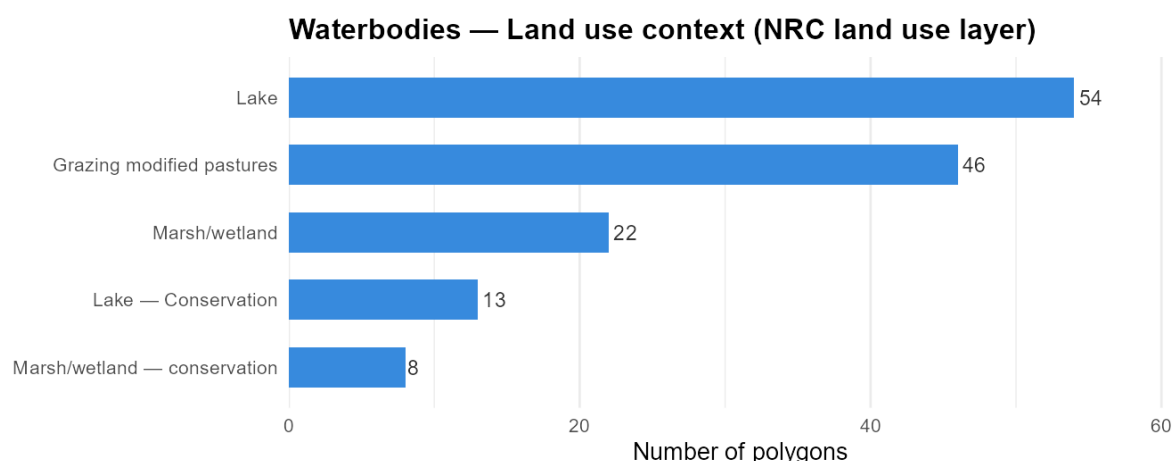


**Figure 14.** Land use context for waterbody polygons ( $n = 192$ , excluding eight incorrectly typed polygons), showing the five most common categories based on NRC high-resolution land use data.

## 7.5 Heathlands (including gumlands)

Gumlands are a rare, low-nutrient heathland ecosystem found in northern Aotearoa, primarily in Northland and Auckland, that develop on soils formerly occupied by kauri forest (Taylor et al., 2025). They are shrub-dominated heathlands characterised by sclerophyllous species, most commonly mānuka (*Leptospermum hoipolloi*), tangle fern (*Gleichenia dicarpa*), and sedges (*Machaerina teretifolia* and *Schoenus brevifolius*). They also host a range of threatened species only found with gumlands in New Zealand (Taylor et al., 2025).

Heathland ecosystems, of which gumlands are a globally unique example, are recognised internationally as threatened ecosystems confronting widespread biodiversity loss and long-term decline (Fagúndez, 2013). Gumlands are considered critically endangered based on more than 80% decline in their distribution over the last 50 years (Holdaway et al., 2012). They are ranked second equal among 92 naturally uncommon ecosystems for research priority by DOC (2020).

These systems are generally classified as wetlands due to the presence of an impermeable hardpan that restricts drainage, although their classification remains somewhat ambiguous and they have been considered a problematic type of wetland (Johnson & Gerbeaux, 2004). At a fine scale, gumland plant communities are not homogeneous, forming a mosaic of wet and dry habitats driven by variations in the depth of the siliceous hardpan, with mānuka dominant on better-drained sites, sedges prevalent as drainage decreases, and tangle fern dominating the wettest areas (Taylor et al., 2025).

A gumland site that appears dry can have water periodically present because of the hard pan but not always obvious; individual sites may encompass both wetland and non-wetland conditions across short distances, complicating their delineation and classification. This is a definition problem rather than a technical one, so it is best that heathland areas are considered as gumlands until proven otherwise.

Here we include the terms wet heathland and ironstone heathland as defined in the Regional Policy Statement (NRC, 2016) and Regional Plan for Northland (NRC, 2026), within the definition of gumland ecosystems (Martin et al., 2019). It is likely that some of the heathlands, including gumlands mapped here are not wet but further ground truthing would be needed to resolve this. Uncertainty around their successional trajectories further complicates their definition, as gumlands can be difficult to distinguish from areas of slowly regenerating forest on low fertility substrates.

Gumlands were mapped using a machine learning approach trained on LiDAR and spectral imagery, with vegetation indicators (particularly mānuka and tangle fern) used as proxies; however, the absence of reliable soil data resulted in substantial confusion with regenerating scrub and a high rate of false positives (Macdonald et al., 2024).

### **Wetland type accuracy**

Of the 200 gumland polygons assessed through desktop validation, the wetland type was correctly identified in 136 polygons (68%), with 63 (31.5%) assessed as uncertain and one (0.5%) as incorrect. Gumland vegetation can appear visually similar to regenerating native forest and scrub in aerial imagery, making confident type assignment difficult, particularly in the smaller size classes. Uncertainty peaked in the 50–500m<sup>2</sup> class where 20 of 40 polygons (50%) could not be confidently assigned. Accuracy improved markedly with polygon size, with all 25 polygons greater than 5ha correctly typed and 28 of 35 polygons in the 0.5–5ha class correctly identified. Of the 200 polygons assessed, 198 (99%) were confirmed as natural wetlands and two (1%) were uncertain.

## Gumland – Wetland type accuracy by size class

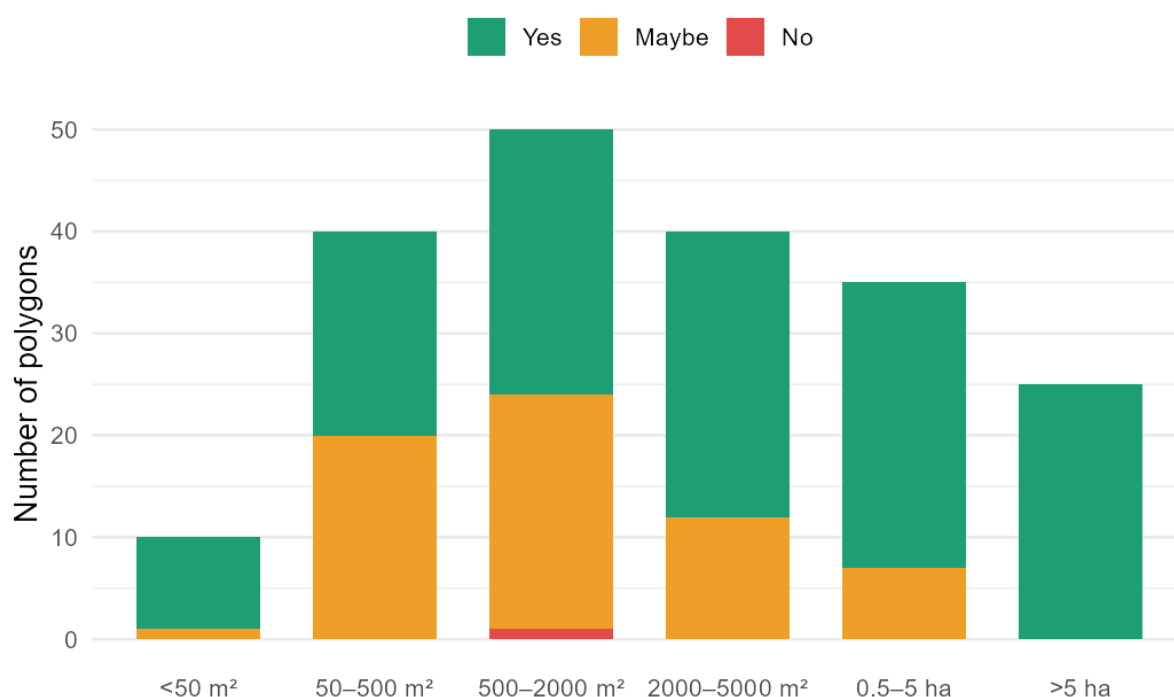


**Figure 15.** Wetland type accuracy by size class for sampled gumland polygons ( $n = 200$ ). Dark green = correct wetland type (Yes); amber = uncertain (Maybe); red = incorrect wetland type (No).

### Confidence

Overall mapping confidence was moderate, with an almost even split between High and Medium confidence ratings. Of the 199 polygons confirmed or uncertain as gumland, 101 (50.8%) were rated as High confidence, 96 (48.2%) as Medium confidence, and two (1.0%) as Low confidence. The high proportion of Medium confidence reflects the inherent difficulty in confirming gumland identity from aerial imagery, particularly where gumland grades into regenerating scrub or where the presence of a gumland pan cannot be confirmed. The one incorrectly typed polygon was excluded from this summary.

A known area of gumland at the Mangawhai North Head Remnant (ROD014), identified within the Rodney Ecological District (Northland Conservancy) (Goldwater et al., 2012), was not mapped as gumland in the LiDAR-derived dataset. This may be due to the clearing of the vegetation, the small size of the remnant or successional change, with the site having potentially regenerated into forest that no longer meets the shrubland–gumland structural definition. However, it is also not captured within the NRC layer “Known wetlands not mapped by machine learning”. Another area in the Waipoua Forest known as the Tarahoka Clearing in a known gumland site but was not mapped as such by mapping.

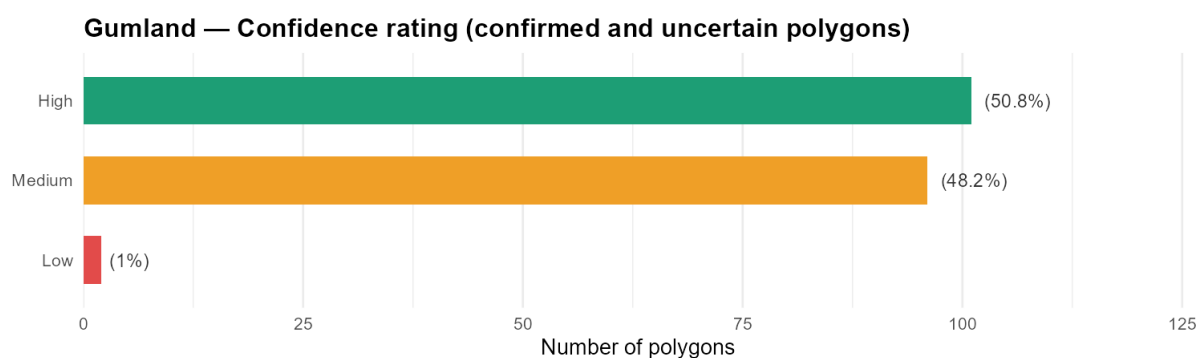


**Figure 16.** Confidence ratings for sampled gumland polygons ( $n = 199$ , excluding one incorrectly typed polygon). High confidence = 101, Medium confidence = 96, Low confidence = 2.

### Land use context

The majority of gumland polygons occurred within native vegetation contexts, consistent with the ecology of gumland, which typically occurs within or adjacent to areas of indigenous vegetation regenerating across Northland. Based on NRC high-resolution land use data, the five most common land use categories were Residual native cover (109 polygons), Marsh/wetland — conservation (18 polygons), National park (12 polygons), Habitat/species management area (10 polygons), and Marsh/wetland (8 polygons). The dominance of residual native cover reflects the strong association between gumland vegetation and remnant indigenous land cover across the Northland landscape.

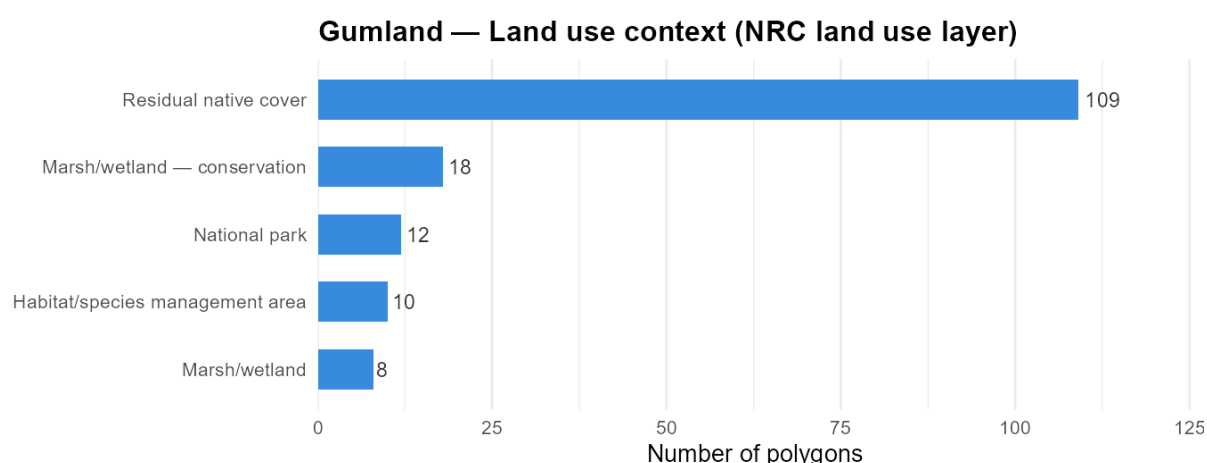


**Figure 17.** Land use context for gumland polygons ( $n = 199$ , excluding one incorrectly typed polygon), showing the five most common categories based on NRC high-resolution land use data.

### Significant wetlands

Twenty-five gumland polygons were flagged as potentially ecologically significant, all within the largest size class (>5ha). Of these, 24 were rated High confidence and one Medium confidence. The Medium confidence rating reflected some residual uncertainty in confirming wetland type from aerial imagery, even at larger polygon sizes. These sites are likely to warrant priority consideration under the Regional Policy Statement for Northland (NRC, 2016) significance provisions and may benefit from early field verification to confirm their ecological values.

## 8. Limitations of the QA Assessment

The QA assessment relied primarily on desktop validation using aerial imagery and other spatial datasets. While this approach provides valuable insight into mapping performance, it cannot fully substitute for field verification. Limitations of the desktop approach include variable aerial imagery quality across the region, seasonal vegetation changes, and differences in capture dates between imagery sources. Photoblique imagery, while useful for oblique views of vegetation structure, provides point-based coverage rather than continuous spatial data and was not available for all assessed polygons. Certain wetland types, particularly forest swamps or wetlands with subtle hydrological expression hidden by canopy, may not be reliably identified through remote sensing alone.

Although wetlands were sampled across territorial local authority districts and ecological districts to ensure broad regional coverage, and across a range of size classes from less than 50m<sup>2</sup> to greater than 5ha, spatial variation in mapping performance was not formally assessed. This is a notable gap given that wetland loss and representation vary markedly across Northland's ecological districts (Clarkson & Price, 2022), suggesting that mapping performance may similarly vary by district or catchment due to differences in vegetation structure, land use intensity, imagery quality, and environmental context. As a result, performance in a particular district may be better or worse than the regional average reported here. Future QA rounds may benefit from explicitly analysing accuracy and confidence by district or catchment to identify whether mapping performance varies systematically across the region.

The current mangrove mapping applied a 50cm height filter to exclude non-mangrove vegetation and recognise the Regional Plan seedling rule that excludes seedlings less than 50cm. While intended to improve classification accuracy, introduced new errors by fragmenting mangrove distribution and producing a patchier representation of mangrove extent than is present on the ground. This limitation is increasingly apparent when viewed against imagery updated several years later, where ongoing mangrove expansion means the mapped extent progressively underrepresents current distribution.

For saltmarsh, a consistent mapping methodology was applied across all wetland layers; however, this approach was not well suited to the finer-scale and more complex boundaries characteristic of saltmarsh, and the current saltmarsh layer is likely less accurate than the previous saltmarsh mapping as a result (Macdonald et al., 2020).

## 9. Recommendations

Key recommendations arising from the QA assessment include:

1. Improving mapping accuracy:
  - a) targeted field validation of wetlands with low mapping confidence
  - b) improved detection of forest swamps using additional environmental predictors
  - c) integration of soil datasets and geomorphic indicators into modelling
2. Inventory and maintenance:
  - a) development of a regional wetland inventory
  - b) establishment of processes for updating the mapping as new information becomes available
3. Future QA:
  - a) analysis of mapping accuracy and confidence by ecological district or catchment in future QA rounds to identify spatial variation in mapping performance

Recommendations for improving wetland mapping accuracy, maintaining an up-to-date regional wetland inventory, and strengthening future QA are provided in Table 5. These recommendations are prioritised according to likely impact and feasibility.

The highest priority action is targeted field validation, focusing on polygons flagged as low confidence in the QA assessment and, for unsampled polygons, using wetland class/type datasets compiled from the wetland geodatabase to prioritise field checks by wetland type and size class. Ideally, every polygon in the wetland geodatabase would have an assigned confidence score, providing a consistent basis for prioritising field verification and monitoring across the full dataset rather than the sampled subset alone.

The high-resolution NRC land-use information layer (Law & Ardo, 2023) also presents an opportunity to improve future machine learning models by incorporating land-use context as a predictor variable, potentially improving the distinction between wetland and non-wetland features in modified landscapes.

Medium-priority actions focus on improving the underlying modelling inputs, maintaining the currency of the inventory, and strengthening spatial coverage through cross-checking against existing ecological records.

**Table 5.** Indicative improvement and maintenance roadmap.

| Improvement action                                                      | Priority | Trigger               | Likely data source           |
|-------------------------------------------------------------------------|----------|-----------------------|------------------------------|
| Targeted field checks for forest swamps, gumlands and pastoral wetlands | High     | Low confidence flags  | NRC / DOC field surveys      |
| Integration of soils and geomorphic data                                | Medium   | Dataset refresh cycle | S-map, regional soils        |
| Update inventory using Consent and Land Management data                 | Medium   | Annual review         | Consents and Lands databases |
| Model retraining using updated LiDAR data                               | Medium   | New LiDAR capture     | NRC LiDAR programme          |

| Improvement action                                                                  | Priority | Trigger               | Likely data source                                                 |
|-------------------------------------------------------------------------------------|----------|-----------------------|--------------------------------------------------------------------|
| Cross-check known wetland records against mapping layers to identify unmapped sites | Medium   | Dataset review        | PNAP reports, DOC ecological district surveys, NRC wetland records |
| Incorporate NRC land-use information layer into machine learning model training     | Medium   | Dataset refresh cycle | Law & Ardo (2023)                                                  |
| Analyse mapping performance by ecological district or catchment                     | Medium   | Next QA round         | QA output data, Clarkson & Price (2022)                            |

The mangrove height filter threshold should be reviewed in light of ongoing mangrove expansion and the patchiness introduced in the current mapping. Revised mapping using updated imagery would better reflect current mangrove distribution across the region. For saltmarsh, future mapping should revert to or build upon the previous saltmarsh-specific methodology (Macdonald et al., 2020), which produced more accurate results than the generalised approach applied in the current dataset. A dedicated higher-resolution methodology tailored to saltmarsh boundaries and community structure would substantially improve classification accuracy.

A systematic cross-check of known wetland records against current mapping layers is recommended to identify potential gaps in coverage. For example, an area of gumland at the Mangawhai North Head Remnant (ROD014), identified within the Rodney Ecological District (Northland Conservancy) (Goldwater et al., 2012), was not mapped as gumland in the LiDAR-derived dataset and is also absent from the NRC layer "Known wetlands not mapped by machine learning."

This may reflect the small size of the remnant or successional change, with the site potentially having regenerated into forest that no longer meets the shrubland–gumland structural definition. Cross-checking against existing sources such as Protected Natural Areas Programme (PNAP) reports and DOC ecological district surveys would help identify similar gaps across the region.

The fine-scale geo-segment datasets underlying the modelling are available for internal use and can assist with iterative validation and refinement of the mapping layers as new ground-truth information becomes available.

## 10. Recommended Use of Wetland Mapping Layers

The wetland mapping layers should be interpreted as indicative datasets suitable for:

- regional-scale planning
- ecological inventory development

Where precise wetland boundaries or confirmation of wetland status is required, field investigation by a qualified wetland specialist should be undertaken. The strengths and limitations of each layer, and guidance on when field verification is required, are summarised in Table 6.

**Table 6.** Recommended uses and limitations by wetland layer

| Layer                        | Suitable uses                                                                          | Key limitations                                                                                                                                                                                            | Field verification required when...                                               |
|------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Combined freshwater wetlands | Regional planning, screening, prioritisation, identifying previously unmapped wetlands | Difficulty detecting wetlands beneath forest canopy; confusion with pastoral wetlands                                                                                                                      | Boundaries or type required for consents                                          |
| Mangroves                    | Coastal planning, extent monitoring, restoration planning                              | Upper margin delineation; height filter introduces patchiness                                                                                                                                              | Legal boundary disputes; current extent assessment                                |
| Saltmarsh                    | Estuary management, restoration planning, biodiversity assessment                      | Boundary delineation uncertain where saltmarsh grades into mangrove or intertidal mud; seasonal and tidal variability affects extent; current layer less accurate than previous saltmarsh-specific mapping | Precise extent or condition required; boundary confirmation                       |
| Waterbodies                  | Catchment assessment, lake inventory, dune lake identification                         | Some waterbodies may be seasonal or ephemeral; small waterbodies difficult to characterise from aerial imagery                                                                                             | Determining wetland status                                                        |
| Gumlands / wet heathlands    | Biodiversity prioritisation, screening for significant wetlands                        | Visual similarity to regenerating scrub; pan presence difficult to confirm from aerial imagery; mapped extent may include false positives due to spectral confusion with mānuka scrub                      | Any regulatory decision; confirming gumland pan presence; significance assessment |

## 11. Conclusion

The wetland mapping layers developed for Northland represent a significant step forward in understanding the regional distribution and extent of wetlands across the region. The QA assessment evaluated 1,000 wetland polygons across five wetland classes through stratified desktop validation, providing a statistically defensible basis for evaluating mapping performance and guiding appropriate use of the datasets.

Mapping confidence varied markedly across wetland types, reflecting differences in the structural and visual distinctiveness of each community from aerial imagery. Mangroves were the most reliably mapped wetland type, with 97.8% of polygons rated as High confidence, consistent with the structural distinctiveness of mangrove canopy in coastal and estuarine settings. Saltmarsh performed well overall (83.0% High confidence), though boundary delineation was more variable, particularly where saltmarsh grades into mangrove or intertidal mud at smaller polygon sizes. Waterbodies showed moderate confidence (74.5% High), with the primary source of uncertainty being the difficulty of distinguishing waterbodies from farm dams and other artificial structures. Gumlands showed a near-equal split between High (50.8%) and Medium (48.2%) confidence, reflecting the inherent difficulty of distinguishing gumland vegetation from structurally similar regenerating scrub without field verification. Freshwater wetlands were the most challenging wetland type to map with confidence, with 47.9% of polygons rated as Low confidence, driven largely by confusion with damp pasture and modified grassland in agricultural landscapes and wetlands obscured by forest canopies.

Across all wetland types, mapping accuracy was consistently highest in the larger size classes, with uncertain or incorrect assignments concentrated in polygons below 500m<sup>2</sup>. This pattern reflects the limitations of aerial imagery for characterising small or transitional wetland features and highlights the value of field verification for smaller polygons in high-priority settings. Potentially significant wetlands (≥5ha) were generally mapped with high accuracy and confidence across all wetland types, with the exception of freshwater wetlands where four of the 25 largest polygons were recorded as a different wetland class and require field verification to confirm their ecological values.

Land use context varied predictably across wetland types. Mangroves and saltmarsh occurred almost entirely within intertidal saline contexts, consistent with their coastal ecology. Freshwater wetlands and waterbodies were strongly associated with grazing modified pastures, reflecting the prevalence of modified and artificial water features within Northland's agricultural landscape. Gumlands were predominantly associated with residual native cover and conservation land, consistent with their occurrence within remnant indigenous vegetation.

Potentially significant wetlands (≥5ha) were generally mapped with high accuracy and confidence across all wetland types, indicating that larger wetland stands are reliably captured in the mapping. Exceptions include freshwater wetlands, where four of the 25 largest polygons were recorded as a different wetland class, and waterbodies, where six of the 25 significant polygons were confirmed as artificial. Field verification is recommended for all potentially significant wetlands where regulatory or consent-related decisions are required.

The wetland layers are best interpreted as indicative datasets suitable for regional- and landscape-scale analyses, including landscape assessment, restoration planning, and ecological inventory development. Where precise wetland boundaries or confirmation of wetland status is required, particularly for regulatory or consent-related purposes, field verification by a qualified wetland specialist remains necessary. The validated QA records generated through this assessment provide a valuable labelled dataset that can be used to refine future mapping models, improve training data, and prioritise polygons for field verification in subsequent QA rounds. Continued validation and iterative improvement will further enhance the reliability and usefulness of wetland mapping across the Northland region.

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## Appendix 1: Author Expertise

Marley Ford is an ecological consultant with particular expertise in Northland's wetlands and broader Northern New Zealand ecosystems. He brings an ecosystem-level perspective to his work, integrating knowledge of vegetation, hydrology, and land use to inform assessment, management, and restoration at landscape scales. A core part of his practice involves wetland delineation, vegetation plotting, and ecological mapping, skills that are central to the quality assurance work undertaken in this report.

Marley holds a Bachelor of Applied Science (Biodiversity Management) from Unitec Institute of Technology (2017) and a Master of Environmental Science with Honours from the University of Auckland (2021). He is currently a part-time PhD candidate at the University of Auckland, specialising in gumland ecology.

His areas of expertise span Northern New Zealand terrestrial and freshwater ecosystems, with a strong focus on wetland systems and their ecological functions. He specialises in vascular plants, bryophytes, and lichens, including their identification, ecological relationships, and role within broader ecosystem processes. This taxonomic depth underpins his ability to assess ecosystem condition, identify threats, and support evidence-based management decisions. He has extensive experience in wetland delineation using both desktop and field-based methods, and in the production and interpretation of ecological mapping layers to support regional planning and biodiversity assessment.

He has particular expertise in gumland ecosystems, which are the focus of his doctoral research. His work across terrestrial, freshwater, and gumland systems has developed a strong understanding of ecological connectivity, successional dynamics, and the management interventions required to maintain and restore ecosystem integrity across Northland's diverse environments.

## Appendix 2: Wetland data source

Wetland\_2024\_NewDataset.gdb:

<https://nrcmaps.nrc.govt.nz/portal/home/item.html?id=a8332325ac1542b698d6d5eda88a2537>

## Appendix 3: Imagery Sources Used in Desktop Validation

The following aerial imagery and spatial datasets were used in the desktop validation of wetland mapping layers.

| Dataset                   | Provider    | Notes                                                                                           |
|---------------------------|-------------|-------------------------------------------------------------------------------------------------|
| Aerial imagery            | LINZ / NRC  | Current aerial imagery used as primary validation source                                        |
| Historical aerial imagery | Retrolens   | Used to assess historical wetland extent and land use change – dates vary between 1940s – 1990s |
| Oblique aerial imagery    | Photoblique | Point-based coverage; not available for all assessed polygons. Capture dates vary.              |

## Appendix 4: Table of Figures

|                                                                                                                                                                                                                                                                          |    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Figure 1.</b> View north over the highest ranked pakihi and gumland wetland, Lake Ohia, Northland (Martin et al., 2011). Photograph: A. Macdonald, Biospatial Ltd, 24 March 2023. ....                                                                                | 6  |
| <b>Figure 2.</b> Decision logic for assessing the likelihood of wetland significance under the Northland Regional Policy Statement (NRC, 2016). Mapping indicates likelihood only and does not constitute a determination of significance under statutory criteria. .... | 12 |
| <b>Figure 3.</b> Wetland class accuracy by size class for sampled freshwater wetland polygons (n = 200). Dark green = accurate wetland class (Yes); amber = uncertain (Maybe); red = inaccurate (No). ....                                                               | 18 |
| <b>Figure 4.</b> Confidence ratings for sampled freshwater wetland polygons (n = 192, excluding eight incorrectly typed polygons). High confidence = 58, Medium confidence = 42, Low confidence = 92..                                                                   | 18 |
| <b>Figure 5.</b> Land use context for freshwater wetland polygons (n = 192, excluding eight incorrectly typed polygons), showing the five most common categories based on NRC high-resolution land use data..                                                            | 19 |
| <b>Figure 6.</b> Wetland type accuracy by size class for sampled mangrove polygons (n = 200). Dark green = correct wetland type (Yes); light green = partially correct (Partly); amber = uncertain (Maybe); red = incorrect wetland type (No). ....                      | 20 |
| <b>Figure 7.</b> Confidence ratings for sampled mangrove polygons (n = 181, excluding incorrectly typed polygons). High confidence = 177, Medium confidence = 1, Low confidence = 3. ....                                                                                | 20 |
| <b>Figure 8.</b> Land use context for mangrove polygons (n = 176, excluding incorrectly typed polygons), showing the five most common categories based on NRC high-resolution land use data. ....                                                                        | 21 |
| <b>Figure 9.</b> Wetland type accuracy by size class for sampled saltmarsh polygons (n = 200). Dark green = correct wetland type (Yes); amber = uncertain (Maybe). ....                                                                                                  | 22 |
| <b>Figure 10.</b> Confidence ratings for sampled saltmarsh polygons (n = 200). High confidence = 166, Medium confidence = 19, Low confidence = 15.....                                                                                                                   | 22 |
| <b>Figure 11.</b> Land use context for saltmarsh polygons (n = 200), based on NRC high-resolution land use data. Marsh/wetland — saline was the dominant context (199 polygons), with one polygon occurring within Estuary/coastal waters — conservation.....            | 23 |
| <b>Figure 12.</b> Wetland type accuracy by size class for sampled waterbody polygons (n = 200). Dark green = correct wetland type (Yes); amber = uncertain (Maybe); red = incorrect wetland type (No).....                                                               | 24 |
| <b>Figure 13.</b> Confidence ratings for sampled waterbody polygons (n = 192, excluding eight incorrectly typed polygons). High confidence = 143, Medium confidence = 35, Low confidence = 14. ....                                                                      | 24 |
| <b>Figure 14.</b> Land use context for waterbody polygons (n = 192, excluding eight incorrectly typed polygons), showing the five most common categories based on NRC high-resolution land use data..                                                                    | 25 |
| <b>Figure 15.</b> Wetland type accuracy by size class for sampled gumland polygons (n = 200). Dark green = correct wetland type (Yes); amber = uncertain (Maybe); red = incorrect wetland type (No).....                                                                 | 27 |
| <b>Figure 16.</b> Confidence ratings for sampled gumland polygons (n = 199, excluding one incorrectly typed polygon). High confidence = 101, Medium confidence = 96, Low confidence = 2.....                                                                             | 28 |
| <b>Figure 17.</b> Land use context for gumland polygons (n = 199, excluding one incorrectly typed polygon), showing the five most common categories based on NRC high-resolution land use data. ....                                                                     | 28 |

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